5-2020

A Comparative Ecological Study of Limestone and Dolomite Glades in the Ozark Mountains of Northwest Arkansas

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A Comparative Ecological Study of Limestone and Dolomite Glades
in the Ozark Mountains of Northwest Arkansas

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Biology

by

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University of Arkansas
Bachelor of Science in Biology, 2016

May 2020
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

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Abstract

Glades are one of the many habitats that exist in the Arkansas Ozarks and contribute to the overall biodiversity of the state of Arkansas. For this study, five dolomite glades and five limestone glades in the Ozarks of northwest Arkansas were studied from March to October in the years 2017 and 2018 to determine the similarities or differences that might be present. One hundred and fifteen vascular plant taxa were documented in the dolomite glades and one hundred and three vascular plant taxa were documented in the limestone glades. Forty-six vascular plant taxa were unique to the dolomite glades and thirty-four vascular plant taxa were unique to the limestone glades. The species richness and total abundance of the dolomite glades were slightly higher than the limestone glades. Shannon's diversity index and Simpson's diversity index for the dolomite and limestone glades were not significantly different. Factors that might account for the observed differences include washout after heavy rains, tree fall, wild hog activity, and mechanical removal of eastern red-cedar. The dolomite and limestone glades had sixty-nine taxa in common with the most abundant species being little bluestem in both glade types. Little bluestem occurred in all five dolomite and all five limestone glades. Drones were used to obtain 3D dense point cloud and orthomosaic images of glades to emphasize differences in topography of limestone and dolomite glades. As a result of the diversity indices being similar, the sixty-nine taxa in common, and the minor differences in species richness and total abundance for the dolomite and limestone glades, the two types of glades could potentially be managed using similar practices, such as prescribed fire and mechanical removal of eastern red-cedar, without having detrimental effects on vascular plant diversity.

Acknowledgements

This study could not have been completed without the help of the Arkansas Natural Heritage Commission, who provided me with access to the land they manage as well as the Arkansas Native Plant Society, who provided funding for this study. Angela Booth, Ashley Booth, Erin Sisco, and Karen Willard assisted with field work. Thanks to Theo Witsell, Karen Willard, James Beck, Justin Thomas, and Dr. Johnny Gentry who helped with plant identification. Appreciation is extended to Angie Otting, Justin Rollans, Nathan Sorey, Sarah Gray, and Dr. Jason Tullis for their help with drone imaging and processing. Thanks to my committee members—Dr. Steve Stephenson, Dr. Jason Tullis, and Dr. Johnnie Gentry—for all the support and direction they have provided during this study.

Table of Contents

Introduction

History of the Vegetation in the Ozarks

The Ozarks, which extend from Missouri and Arkansas to Oklahoma and Tennessee, contain various kinds of habitats for a wide variety of different plants. The Ozarks currently harbor riparian habitats, grasslands and prairies, wetlands, forests, mountainous habitats, and glades among others. Historically, though, the composition of the Ozarks is much less clear. Although the Ozarks exist over a large area of land, there is very little historical documentation about the vegetation of the Ozarks prior to the early 1800s.

Some of the earliest descriptions of the vegetation of the Ozarks in Arkansas come from surveyors such as William Dunbar and George Hunter, who made forays into Arkansas in the fall of 1804 (Strausberg and Hough, 1997). Dunbar (1807) made note of different species of oak (*Quercus* spp.) and hickory (*Carya* spp.), as well as pine (*Pinus* spp.) trees at higher elevations. He also mentioned the open land that the Native Americans cleared and burned to attract game in the spring (Dunbar, 1807). At lower elevations in the valleys of the Ozarks, elm (*Ulmus* spp.), maple (*Acer* spp.), ash (*Fraxinus* spp.), persimmon (*Diospyros virginiana* L.), pawpaw (*Asimina triloba* [L.] Dunal), oaks, and sycamore (*Platanus occidentalis* L.) were noted by Henry Schoolcraft as he travelled through the Ozarks in 1818 (Schoolcraft, 1819). Schoolcraft also made note of some of the trees growing at the higher elevations as well, mostly yellow pines (*Pinus* spp.) and post oak (*Quercus stellata* Wangenh.).

Phillip Chaney (1990) made use of a surveyor's notes from 1832, identifying witness trees to determine the frequencies of different tree species in the Ozarks in 1832. Chaney indicated that white oak (*Quercus alba* L.), post oak, black oak (*Quercus velutina* Lam. in Lam. et al.) and northern red oak (*Quercus rubra* L.) were the most common trees, with species of

hickory (*Carya* spp.) and elm (*Ulmus* spp.) being the next most common. Several other surveyors and explorers made note of pine stands on slopes and ridges as well, consisting of yellow pines and slash pine (*Pinus* spp.) (Strausberg and Hough, 1997).

There is very little information on what the vegetation of the Ozarks may have looked like due to the small population of Native Americans and early Euro-American settlers before population increases in the early to mid-1800s of Euro-American settlers and the lack of interest in or reason to document the flora of the Ozarks (Bragg, 2005). However, surveyor's notes and the accounts of early travelers indicate that the Missouri and Arkansas Ozarks may have been more open than they are at present (Foti, 2004; Nelson, 2012; Hanberry et al., 2014a).

As the remaining Native American population was forced out of the Ozarks, some of the first Euro-American settlers in the Ozarks were able to move in. Most of these first Euro-American settlers did not practice large scale agriculture but instead hunted for food and let their livestock roam free to feed on the forest understory (Schoolcraft, 1819). By the mid-1800s, though, agriculture became a larger practice as roads and streams allowed penetration into the central Ozark forest area and the transportation of goods (Sabo, 1990b). The expansion of railroads west into the forest of the Ozarks throughout the 1860s and 1870s further expanded the market for agriculture products (Sabo, 1990b). The expansion of the railroads west into the Ozarks and other areas of Arkansas also enabled a new market to arise—timber (Sabo, 1990b; Strausberg and Hough, 1997). Logging, on a smaller scale, existed in the Ozark forests for decades prior to the railroad expansion of the 1860s and 1870s in order to build settlements and provide products that settlers needed (Sabo, 1990b; Strausberg and Hough, 1997; Guyette and Larson, 2000).

However, by 1879 logging in the Ozark forests was very popular and widespread due to the arrival of commercial logging companies and the development of more efficient logging techniques (Strausberg and Hough, 1997). The large majority of the timber companies would cut all of the timber on a piece of land and then abandon the land for a new parcel (Strausberg and Hough, 1997). There were a few timber companies that would select only the best trees that would gain the best profit for cutting and then leave the poorer quality trees before moving onto a new piece of land (Strausberg and Hough, 1997). The most profitable species that were the most often cut in the Ozarks were species of pine, black cherry (*Prunus serotina* Ehrh.), black walnut (*Juglans nigra* L.), eastern red-cedar (*Juniperus virginiana* L. var. *virginiana*), white oak, and other species of oak (Pitcaithley, 1976; Strausberg and Hough, 1997).

Logging in the Ozarks continued well into the 1900s, with 1909 being the peak of the logging period and seeing 2.1 billion board feet of lumber produced in Arkansas alone (Smith, 1986; Benac and Flader, 2004). By the 1910s, there was very little good quality pine left throughout the Missouri and Arkansas Ozarks (Benac and Flader, 2004). Although there was little pine left to log, there remained decent stands of hardwoods for logging (Benac and Flader, 2004). This marked the beginning of the decline of the excessive logging of the Ozarks of Arkansas and Missouri (Strausberg and Hough, 1997). Logging continues in both areas to the present day but is done on a much smaller scale than was seen in the early 1900s.

Logging in Arkansas from 1879 to the 1920s resulted in 8.1 million hectares out of 8.9 million hectares of forest land having been previously cut (Bruner, 1930). In the Missouri Ozarks, by the time large lumber companies had become less common in 1910, there remained less than one-tenth of the previously abundant pine stands (Benac and Flader, 2004). One of the impacts of this large-scale logging was the removal of habitat that was essential to the survival of

some species and the decline of game species due to the lack of cover (Sabo, 1990b). Logging large tracts of land also exacerbated soil erosion by loosening the soil and leaving it exposed to be washed or blown away (Sabo, 1990b). Soil erosion led to the alteration of hydrology in the Ozarks as excessive loosened sediment got into streams and springs (Sabo, 1990b).

The forests of the Ozarks in Arkansas were also burned annually by residents, beginning with Euro-American settlement in the mid-1800s and continuing into the 1900s (Koen, 1939; Strausberg and Hough, 1997). Annual burning was a practice that was implemented before logging and increased during the heavy logging period as fires were common right after logging took place in an area (Bass, 1981; Soucy et al., 2005). The forests of the Ozarks in Arkansas were burned during the spring and fall for several reasons, including clearing the understory for livestock and for controlling insect and arachnid populations, such as ticks and mosquitoes (Koen, 1939; Strausberg and Hough, 1997; Benac and Flader, 2004).

The practice of annual burning of the forest understory and free-roaming livestock became less common after the 1870s due to increases in population in the Arkansas Ozarks after the Civil War, the building of fences to separate properties, and the increasingly more widespread practice of large scale agriculture ventures; however, annual burning and free-range livestock were still common in some areas until the mid-1900s (Strausberg and Hough, 1997; Engbring et al., 2008).

The burning of forests to increase forage for free-roaming livestock and produce pasture land is a practice that had been implemented and maintained for decades leading into the early 1900s, and the continuation of this practice in combination with intensive logging had detrimental results for the Ozark forest landscape (Strausberg and Hough, 1997). In particular, it was noted by Nelson (2012) that it was the yearly burning of the forest understory in

combination with the continued allowance of foraging of this understory by free-roaming livestock that was most detrimental to the Ozark forests after large scale logging practices took place. As a result, the act of burning alone is not noted to have had a significant negative impact on the forests of the Ozarks in Arkansas. It is burning in combination with other anthropogenic activities, such as logging and grazing of the forest understory by livestock, that result in negative impacts on forest composition.

The combination of burning and grazing makes it very difficult for new seedlings to establish themselves (Soucy et al., 2005). In addition, logging also removed many of the healthy population of important tree species, such as white oak and short-leaf pine (*Pinus echinata* Mill.), leaving behind a small and poor gene pool to repopulate the area which was exacerbated by burning and grazing (Strausberg and Hough, 1997). The continuation of burning and grazing after heavy logging led to nearly 2.5 million hectares being dominated by red oaks and other hardwoods rather than shortleaf pine as it had been previously in the Missouri Ozarks (Benac and Flader, 2004).

The vegetation of the Missouri and Arkansas Ozarks has adapted to frequent burnings as a result of the Native Americans and early Euro-American settlers who lived in these areas for decades, burning land to increase forage for game species and for agricultural practices (Cutter and Guyette, 1994; Guyette and Spetich, 2003). The oak-dominated forests of the Ozarks in the 1800s and 1900s are believed to have been a result of these frequent burnings (Guyette and Spetich, 2003). With fire suppression becoming a widespread practice in the 1930s, oaks had a harder time regenerating because they are slower growing and could be grown over more quickly by faster growing, fire-intolerant species such as different species of maples (*Acer* spp.) and eastern-red cedar (Soucy et al., 2005; Hanberry et al., 2014b). Hickories have also become a

dominant species in many Ozark forests in Missouri and Arkansas and although they were common historically, they were not a dominant aspect of the Ozark forest (Nelson, 20012; Hanberry et al., 2014b).

Fire suppression allowed for more shade-tolerant, fire-intolerant species, such as red maple (*Acer rubrum* L. var. *rubrum*) and flowering dogwood (*Cornus florida* L.), to establish themselves in the understory (Chapman et al., 2006). These understory species have an advantage over oak seedlings when the canopy is closed because they can grow more quickly under low light conditions than oaks (Chapman et al., 2006).

Several studies, such as those by Chapman et al. (2006) and Hanberry et al. (2014b), showed the necessity of fire in some Ozark forests to help with oak and pine regeneration began appearing in the 1990s, indicating that fire suppression was not ideal for these forests (Cutter and Guyette, 1994; Batek et al., 1999; Dey and Hartman, 2005). The initiation of several research investigations into prescribed burnings to assess changes in forest composition over extended periods of time allowed forest managers to determine how to implement prescribed burnings and which forest ecosystems needed them (Dey and Hartman, 2005; Fan et al., 2012).

Fire suppression in the 1900s is believed to be one of the causes of woody plant invasion into glade habitats, predominantly by eastern red-cedar (Kimmel and Probasco, 1980). As a result, prescribed burnings have been used to attempt to restore glade ecosystems, along with mechanically removing unwanted tree species such as eastern red-cedar, in an attempt to bring back the native grasses and other herbaceous plants (Comer et al., 2011).

Climate and Geology of the Ozarks

The Ozarks of northwest Arkansas geologically are part of the Springfield Plateau (Benton County) and also exist on the boundary of the Salem Plateau (Carroll County) (Dowell

et al., 2005). Northwest Arkansas is covered by a section of the Springfield Plateau that is made up of Lower Mississippian strata, including the Osagean strata (Dowell et al., 2005). This area of the Springfield Plateau is usually referred to as the Boone formation and is mostly comprised of chert and limestone (Knox, 1966; Dowell et al., 2005).

As mentioned previously, the Ozarks of Arkansas encompass a variety of habitats which share a similar climate pattern. The Ozarks of Arkansas have a temperate climate and receive an average of 1192 mm of rain a year according to the U.S. Climate Data website, which takes into account climate data recorded from 1981-2010 (U.S. Climate Data, 2020). According to the U.S. Climate Data website, the average temperature for the Bentonville, Arkansas area is 13.4°C. The annual low temperature is 6.9°C and the annual high is 19.9°C (U.S. Climate Data, 2020).

Glades in the Ozarks

Glades are one of the many habitats that exist in the Arkansas Ozarks. They are defined as open areas usually found within a forest and are characterized by shallow soil and exposed bedrock and can typically be found on side slopes or ridgetops (Baskin and Baskin, 2000). These areas are exposed to high levels of sunlight and drought conditions with high temperatures in the summer, but winters are characterized by more moisture (Baskin and Baskin, 2000, 2003). Glades of the Ozarks in Arkansas can be found on several different types of bedrock, including limestone and dolomite (Baskin and Baskin, 2000). Limestone and dolomite glades of the Ozarks are typically dominated by herbaceous angiosperms, with the dominant grass being little bluestem (*Schizachyrium scoparium* [Michx.] Nash) (Baskin and Baskin, 2000).

Glades of the Ozarks can be invaded by eastern red-cedar and other drought-tolerant trees and shrubs (Baskin and Baskin, 2000). The invasion of the Ozark glades by eastern red-cedar and other woody species corresponds with fire suppression beginning in the mid-20th century by

the U.S. Forest Service (Soucy et al., 2005). Previously, fires had been more common in the Ozarks to clear land for cattle or agriculture, as previously mentioned, preventing eastern red-cedar and other drought-tolerant trees and shrubs from gaining a foothold (Kimmel and Probasco, 1980; Ver Hoef et al., 1993).

The literature indicates that considerable research has been carried out to compare glades of the Midwest and the Ozarks with glades of the southeastern United States (Baskin and Baskin, 2000; Ware, 2002). There also have been several studies relating to the effects of prescribed fires on the vegetation of glade ecosystems (Jenkins and Jenkins, 2006; Duncan et al., 2008). Baskin and Baskin (2000) examined the compositional differences of vegetation in limestone and dolomite glades in the Midwest and the Ozarks as compared to the glades of the southeastern United States. They found that the Midwest and Ozark glades were dominated by little bluestem and other perennial grasses and were easily encroached upon by woody plants without the intervention of fire. Alternatively, Baskin and Baskin (2000) found that glades of the southeastern United States were dominated by annual grasses and didn't require fire or other disturbances to prevent the encroachment of woody species in the glades.

Ware (2002) also examined the differences between the glades of the Ozarks and the southeastern United States. He noted the levelness of the glades of the southeastern United States as compared to the sloping terrain of the glades of the Ozarks. These differences in terrain allow for different amounts of soil erosion and distribution. In the glades of the Ozarks, soil erosion occurs much faster due to the slope of the terrain and allows for a mosaic pattern of plant distribution, with different types of plants intermixed with each other depending on the depth of soil they require (Ware, 2002). In the glades of the southeastern United States there are distinct zones for different types of vegetation due to the even distribution of soil (Ware, 2002).

Jenkins and Jenkins (2006) looked at how prescribed burning affected the vegetation of a savanna-glade complex in Arkansas by sampling burned and unburned plots after two prescribed burns over a six-year period. The sapling layer was most affected by the burns, resulting in a decrease in density (Jenkins and Jenkins, 2006). These authors also found that species making up the ground cover species, prairie grass species, and other savannah and glade species increased in both burned and unburned plots. However, the burned plots displayed a higher percentage increase in cover than the unburned plots (Jenkins and Jenkins, 2006). These authors also noted that burning practices carried out over a longer period of time, rather than just six years, might be more beneficial to the system in causing greater changes in cover, species richness, and diversity.

Duncan et al. (2008) studied the effects of reintroducing prescribed burning to dolomite glades in Alabama. These authors set up twenty-one paired control plots and experimental plots within the glades and burned the experimental plots in April of 2004 and 2005, then sampling them in the proceeding growing season (Duncan et al., 2008). This study showed that after the first fire in 2004, populations of a few species declined significantly but had recovered by the next year and after the next fire in 2005. Duncan et al. (2008) found that initially in 2004 the abundance of several species in the experimental plots was less than that of the same species in the control plots; however, by 2005 there was no significant difference in abundance between the two plot types. These authors also found that populations of small trees were negatively affected by the fires and decreased in number. From this information the authors theorize that burning the glades is beneficial for glade species and can prevent undesirable woody species from taking over (Duncan et al., 2008).

Materials and Methods

The study areas considered in the research reported herein are located (1) within the Devil's Eyebrow Natural Area near Garfield, Arkansas and (2) on another piece of land called the Banks tract, also located near Garfield, Arkansas, off County Road 867 (Fig. 1). The glades used were selected based on accessibility and condition of overgrowth. Two types of glades were studied—limestone glades and dolomite glades (Figs. 2 and 3). Five study sites for each type of glade were established in the two study areas.

All five limestone glades are located within the northern portion of the Devil's Eyebrow Natural Area, and all five dolomite glades are in the Banks tract. Within each glade, three transects were placed randomly, perpendicular to the slope. Along two transects in each glade, three 1 m x 1 m sampling plots were evenly placed along a fifty-meter fiberglass tape (Fig. 4). Along the third transect, four 1 m x 1 m sampling plots were placed evenly using the same fifty-meter fiberglass tape, for a total of ten plots per glade. Most of the glades were on a nonlevel surface, with differences in the severity of slope. The five limestone glades had a grade of 40-58% (22° to 30° slope) and the five dolomite glades had a grade of 20-36% (10° to 20° slope). All five of the dolomite glades faced southwest from 233° to 243° (Table 1). Two of the limestone glades faced northwest, one at 299° and one at 309°. Two more of the limestone glades faced west at 276° and 279° and the last limestone glade faced southeast at 157° (Table 2).

Data were collected every other week from March to October in both 2017 and 2018 (Tables 3 and 4). One to three glades were sampled on each visit due to time constraints. For each plot, all species of plants were recorded or, for any plant which could not be identified in the field, a physical description was recorded, and a specimen was collected to identify later. The

number of individual plants of each species was recorded and the cover class for each species was determined using the Daubenmire cover class method (Daubenmire, 1959). Plant specimens also were collected from areas within the glade but located outside the sampling plots. Specimens were collected using a small garden trowel and placed in a plastic trash bag with a small amount of water to prevent wilting. Specimens were placed into a wooden plant press at the earliest opportunity and left there to dry for one to four weeks. After drying, each specimen was transferred to and stored in the herbarium of the University of Arkansas (UARK) in Fayetteville, Arkansas and later identified. Nomenclature for collected specimens follows Smith (1994) and Gentry et al. (2013).

Images of Lepidoptera, including moths, butterflies, and caterpillars, were taken whenever possible to help document species in the glades. Images were taken using an iPhone 6s and an iPhone SE. Images of Lepidoptera were later identified using *National Audubon Society Field Guide to North American Butterflies*, *Kaufman Field Guide to Butterflies of North America*, *Caterpillars of Eastern North America*, and *Arkansas Butterflies and Moths* (Pyle and National Audubon Society, 1981; Brock and Kaufman, 2003; Wagner, 2005; Spencer, 2014). Nomenclature of Lepidoptera follows Covell (2005) and Pelham (2012).

Soil samples were collected from each study site. A soil sample was collected from each glade using a small garden trowel and placed into a plastic zip-lock bag. Soil was collected at several locations along each of the three transects in each glade. Each sample was placed out to dry on newspaper in a garage or sunroom at the earliest opportunity and left to dry for one to four weeks. After drying, each sample was processed using a rolling pin and soil sieve to exclude rocks. Each sample was then resealed in a plastic zip-lock bag and mailed to Brookside Laboratories, Inc. (New Bremen, Ohio) for analysis. Types of analyses carried out included pH,

total exchange capacity estimated nitrogen release, percent organic matter, and element concentrations in the soil (Tables 5, 6, and 7).

Drone images were obtained for one limestone glade and one dolomite glade. Drone images for dolomite glade number three (G3) were obtained using a GoPro Hero 4 for RGB imaging and the Sequoia sensor on May 8, 2018. Drone images for limestone glade number four (L4) were obtained using a Solo 3DR for RGB imaging and the Sequoia sensor (Fig. 5) on October 24, 2018. All sensors were flown along transects that were parallel with the slope of the two selected glades in order to obtain images of the entire glade (Figs. 6 and 7). Drone images from both dates were processed using Agisoft Metashape to create 3D dense point cloud and orthomosaic images of the dolomite and limestone glades (Figs. 14, 15, 16, and 17).

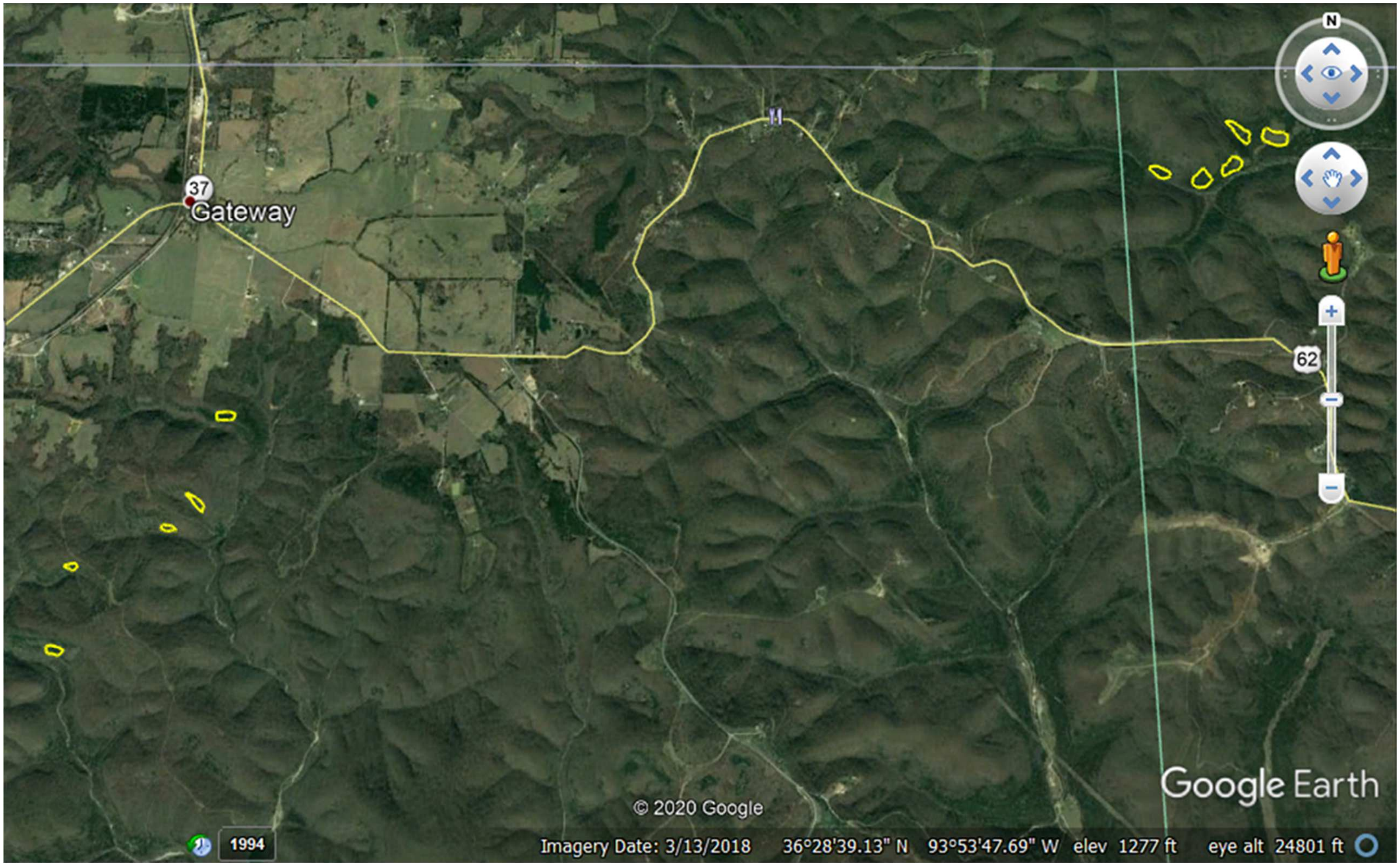

Figure 1. The five limestone glades located in the northern portion of the Devil's Eyebrow Natural Area near Gateway, Arkansas, are indicated by the yellow polygons in the bottom left corner of the map. The five dolomite glades located on the Banks tract near Garfield, Arkansas, are indicated by the yellow polygons in the top right corner of the map. Image by Google Earth

Figure 2. Representative limestone glade used in the present study. This glade, the fifth limestone glade, is located in the northern portion of the Devil's Eyebrow Natural Area. Photo by Brittney Booth

Figure 3. Representative dolomite glades used in the present study. This glade, the fifth dolomite glade, is located in the Banks tract to the northeast of the Devil's Eyebrow Natural Area. Photo by Brittney Booth

Figure 4. An example of a transect, represented by the white line, along with three plots, with the top corner of each plot indicated by a black dot, as they were established at each glade site. Photo by Brittney Booth

Table 1. The aspect and grade (%) of the five dolomite glades investigated in this study and the mean for all five glades. Table by Brittney Booth

Glade	Slope Aspect	Slope Grade (%)
G1	240° Southwest	23
G2	242° Southwest	25
G3	239° Southwest	21
G4	243° Southwest	31
G5	233° Southwest	21
Mean	239˚ Southwest	24

Table 2. The aspect and grade (%) of the five limestone glades investigated in this study and the mean for all five glades. Table by Brittney Booth

Glade	Slope Aspect	Slope Grade (%)
L1	278° West	52
L2	276° West	54
L3	309° Northwest	47
L4	257° West	49
L5	299° Northwest	40
Mean	284˚ West	48

Table 3. Visits to limestone and dolomite glades made in the 2017 field season. Table by Brittney Booth

Glade Visits for 2017							
Glade Type	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Visit 7
Dolomite Glades	4/28/2017	5/26/2017	6/22/2017	7/20/2017	8/27/2017	9/23/2017	N/A
Limestone Glades	4/15/2017	5/16/2017	6/8/2017	7/6/2017	8/3/2017	9/10/2017	10/14/2017

Table 4. Visits to limestone and dolomite glades made in the 2018 field season. Table by Brittney Booth

Glade Visits for 2018								
Glade Type	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Visit 7	Visit 8
Dolomite Glades	3/17/2018	4/14/2018	5/12/2018	6/3/2018	7/2/2018	7/25/2018	8/24/2018	9/28/2018
Limestone Glades	3/30/2018	4/27/2018	5/18/2018	6/14/2018	7/12/2018	8/10/2018	9/9/2018	N/A

Figure 5. Image of the drone used, a Solo 3DR with a Sequoia sensor attached, to capture multispectral images of limestone glade 4 on October 24, 2018. Photo by Brittney Booth

Figure 6. Drone image obtained for the third dolomite glade (G3), using a GoPro Hero 4 for RGB imaging. Photo by Justin Rollans.

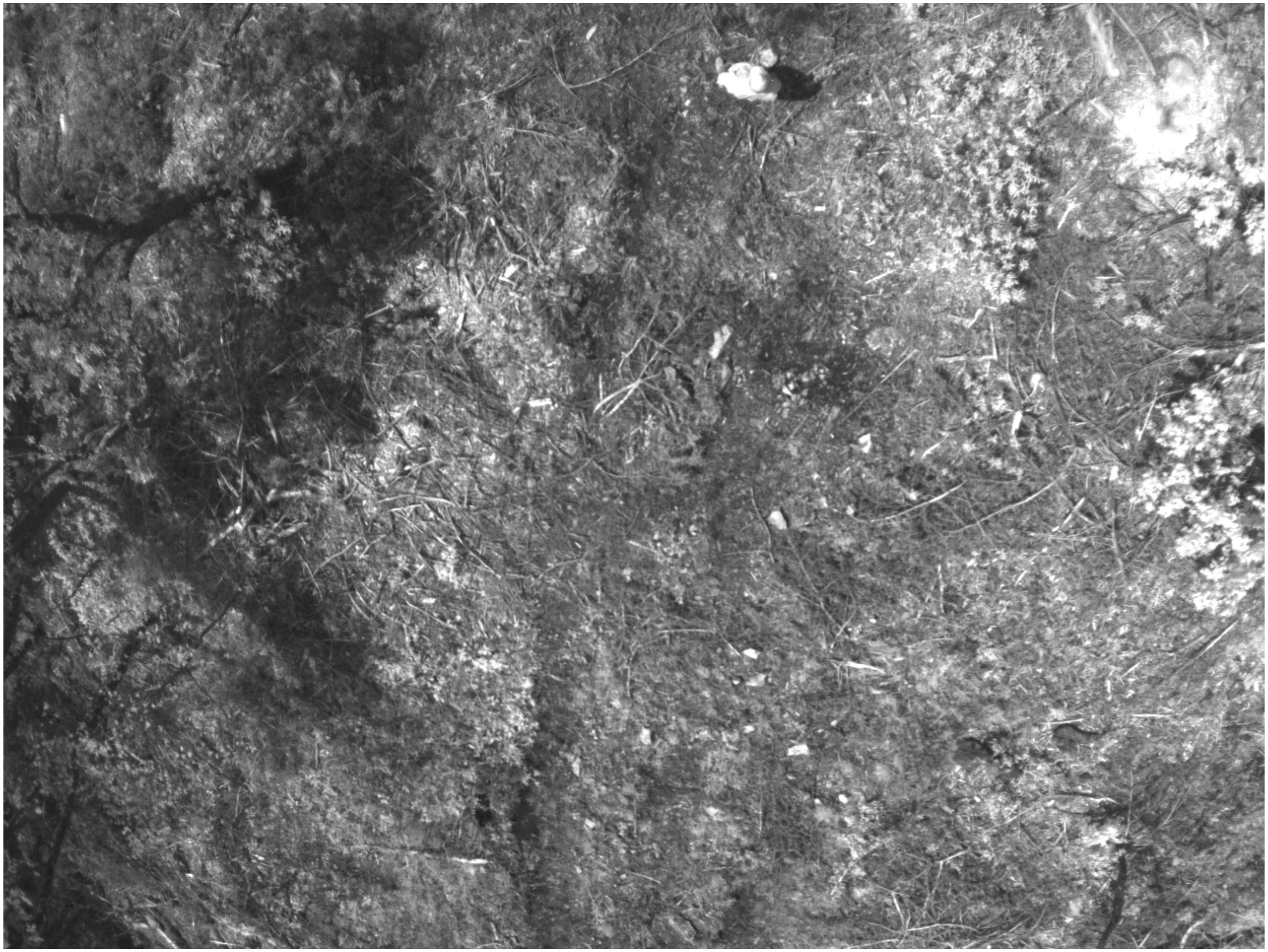

Figure 7. Drone image obtained for the third dolomite glade (G3), using the Sequoia sensor for Rededge (REG) imaging. Photo by Justin Rollans

Results

A total of one hundred forty-nine vascular plant taxa were recorded for the entire study. One hundred fifteen total taxa were recorded for the dolomite glades and one hundred three total taxa were recorded for the limestone glades. Of the one hundred fifteen total taxa recorded for the dolomite glades, one hundred three were identified to the level of species, four were identified to the level of genus, eight were identified to the level of family. There were forty-six taxa that were documented only in the dolomite glades, but never in the limestone glades. Of the one hundred three taxa recorded for the limestone glades, ninety-three were identified to the level of species, five were identified to the level of genus, and five were identified to the level of family. There were thirty-four taxa that were documented only in the limestone glades, but never in the dolomite glades.

The family with the highest number of taxa found in the glades was the Asteraceae, with twenty-eight taxa present. The families with the next highest number of taxa were the Fabaceae and Cyperaceae, with thirteen taxa for each family, followed by the Poaceae with ten taxa and the Euphorbiaceae with seven taxa present. The genera with the highest number of taxa in the Asteraceae was *Symphyotrichum,* with four species. The genus with the highest number of taxa in the Fabaceae was *Lespedeza* and *Baptisia*, each with two species present, and the genus with the highest number of taxa in the Cyperaceae was *Carex* with three species noted. The genus with the highest number of taxa in the Poaceae was *Panicum* with two species noted and the genus with the highest number of taxa in the Euphorbiaceae was *Euphorbia* with three species present. The most abundant species noted included *Rudbeckia hirta* L., *Symphyotrichum* ssp., *Liatris hirsuta* Rydb., *Grindelia lanceolata* Nutt., *Tragia ramosa* Torr., *Galactia volubilis* (L.)

Britton, *Ruellia humilis* Nutt., *Allium canadense* L. var. *lavendulare* (Bates) Ownbey & Aase, and *Schizachyrium scoparium* (Michx.) Nash var. *scoparium* (Fig. 18).

The midpoint range of the cover class for each taxon documented in the dolomite and limestone glades during 2017 and 2018 was used to classify each taxon as being abundant, common, occasional, or rare. The dolomite glades in 2017 (Fig. 8) had five abundant taxa, thirty-one common taxa, thirty occasional taxa, and fourteen rare taxa, for a total of eighty taxa documented in the sampling plots. The dolomite glades in 2018 (Fig. 9) had three abundant taxa, thirty common taxa, twenty-seven occasional taxa, and twelve rare taxa, for a total of seventy-two taxa documented in the sampling plots.

The limestone glades in 2017 (Fig. 8) had one abundant taxon, thirty common taxa, forty-four occasional taxa, and seven rare taxa, for a total of eighty-two taxa documented in the sampling plots. The limestone glades in 2018 (Fig. 9) had one abundant taxon, thirty common taxa, thirty-seven occasional taxa, and seventeen rare taxa, for a total of eighty-five taxa documented in the sampling plots. The most abundant species for the dolomite glades during both field seasons and for the limestone glades during both field seasons was little bluestem (*Schizachyrium scoparium* [Michz.] Nash var. *scoparium*).

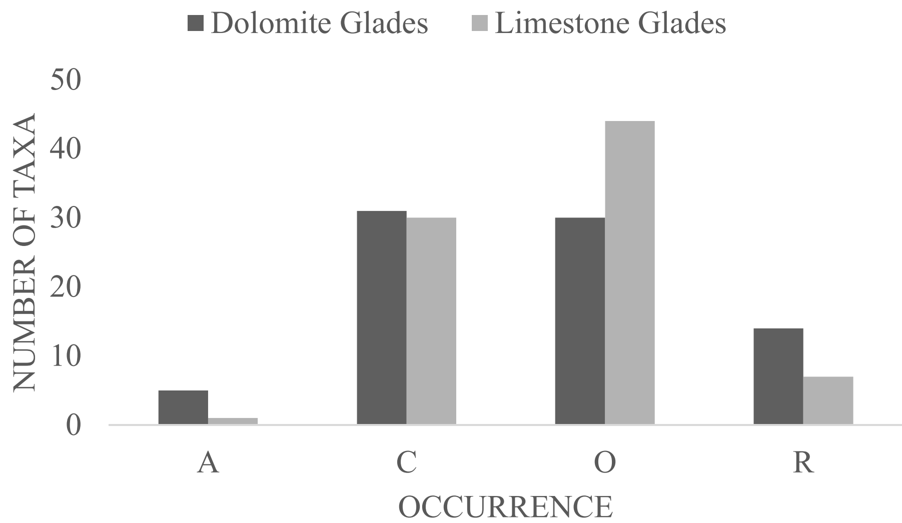

Figure 8. Graph showing the occurrence of eighty taxa documented in fifty sampling plots in the dolomite glades and eighty-two taxa documented in fifty sampling plots in the limestone glades in 2017 as abundant (A), common (C), occasional (O), or rare (R). Figure by Brittney Booth

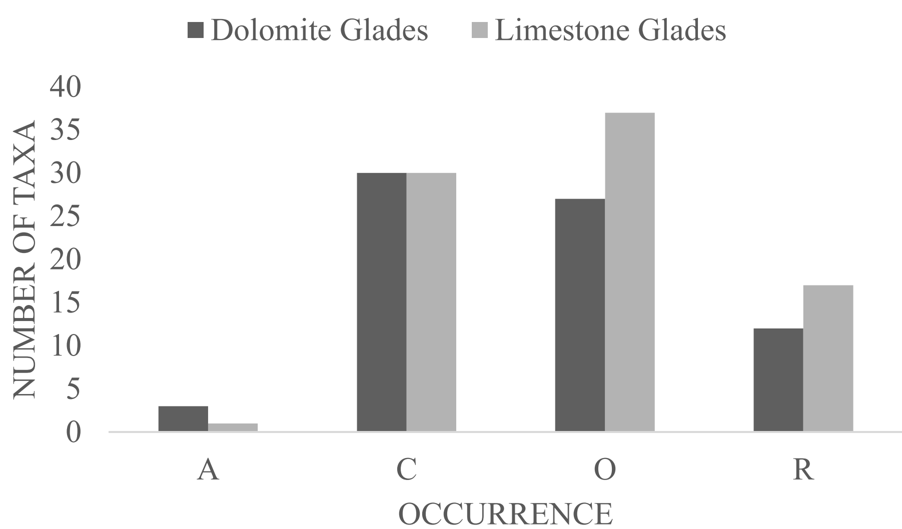

Figure 9. Graph showing the occurrence of seventy-two taxa documented in fifty sampling plots in the dolomite glades and eighty-five taxa documented in fifty sampling plots in the limestone glades in 2018 as abundant (A), common (C), occasional (O), or rare (R). Figure by Brittney Booth

The midpoint range of the cover class for each taxon documented in the dolomite and limestone glades during 2017 and 2018 were used to model phenology of the two types of glades. The midpoint range of the cover class for each taxon documented during each visit (Table 3) to the dolomite glades during 2017 were used to model phenology for the year (Fig. 10). The midpoint range of the cover class for each taxon documented during each visit (Table 4) to the dolomite glades during 2018 were used to model phenology for the year (Fig. 11). The midpoint range of the cover class for each taxon documented during each visit (Table 3) to the limestone glades during 2017 were used to model phenology for the year (Fig. 12). The midpoint range of the cover class for each taxon documented during each visit (Table 4) to the limestone glades during 2018 were used to model phenology for the year (Fig. 13).

A total of eighteen species of Lepidoptera were photographed in the limestone and dolomite glades (Fig. 19). Six species were photographed only in the limestone glades and eleven were photographed only in the dolomite glades. One species was photographed in both the limestone and dolomite glades for a total of seven species photographed in the limestone glades and a total of twelve species photographed in the dolomite glades. Silvery checkerspot (*Chlosyne nycteis* [Doubleday, {1847}]) was photographed in both the limestone and dolomite glades. Drexel's datana (*Datana drexelii* Hy. Edwards, 1884), io moth (*Automeris io* [Fabricius, 1775]), luna moth (*Actias luna* [Linnaeus, 1758]), maple looper (*Parallelia bistriaris* Hübner, 1818), pearl crescent (*Phyciodes tharos* [Drury, 1773]), and pipevine swallowtail (*Battus philenor* [Linnaeus, 1771]) were photographed only in the limestone glades.

Byssus skipper (*Problema byssus* subsp. *kumskaka* [Scudder, 1887]), milkweed tussock caterpillar (*Euchaetes egle* [Drury, 1773]), spicebush swallowtail (*Papilio troilus* subsp. *troilus* Linnaeus, 1758), checkered white (*Pontia protodice* [Boisduval & Le Conte, {1830}]), common

buckeye (*Junonia coenia* Hübner, [1822]), silver-spotted skipper (*Epargyreus clarus* [Cramer, 1775]), hackberry emperor (*Asterocampa celtis* subsp. *celtis* [Boisduval & Le Conte, {1835}]), red-spotted purple (*Limenitis arthemis* subsp. *astyarax* [Fabricius, 1775]), orange sulphur (*Colias eurytheme* Boisduval, 1852), tobacco budworm moth (*Heliothis virescens* [Fabricius, 1777]), and pink prominent (*Hyparpax aurora* [J.E. Smith, 1797]) were photographed only in the dolomite glades.

Analysis of soil samples (Tables 5, 6, and 7) showed that soil of the dolomite glades had a pH range of 7.8-8.1 and soil of the limestone glades had a pH range of 6.8-7.5. The mean value of organic matter in the dolomite glades was 67700 ppm and in the limestone glades it was 83300 ppm. The mean value of calcium in the soil of the dolomite glades was 4306 ppm and in the soil of the limestone glades it was 5332 ppm. The mean value of magnesium in the soil of the dolomite glades was 1086 ppm and in the soil of the limestone glades it was 104 ppm.

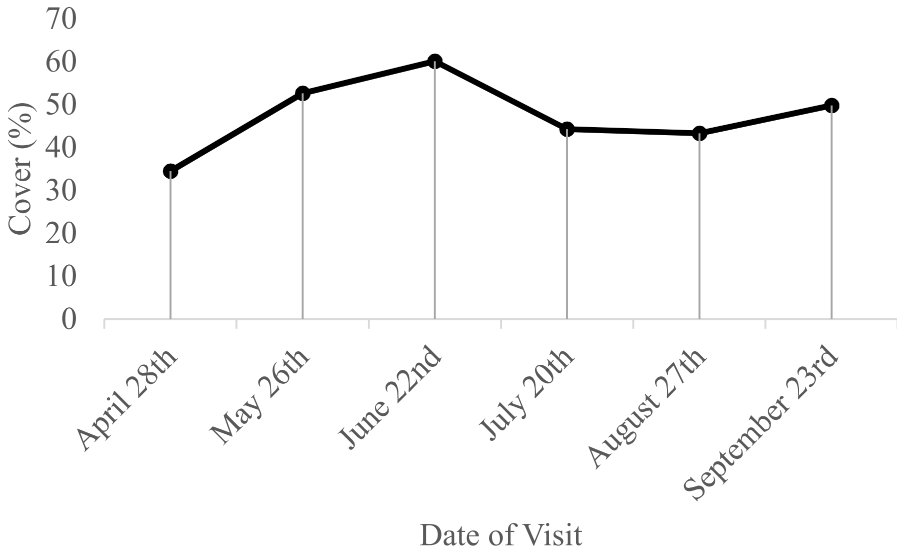

Figure 10. Graph showing the percent cover of all documented taxa in the dolomite glades during each visit of the 2017 field season. Figure by Brittney Booth

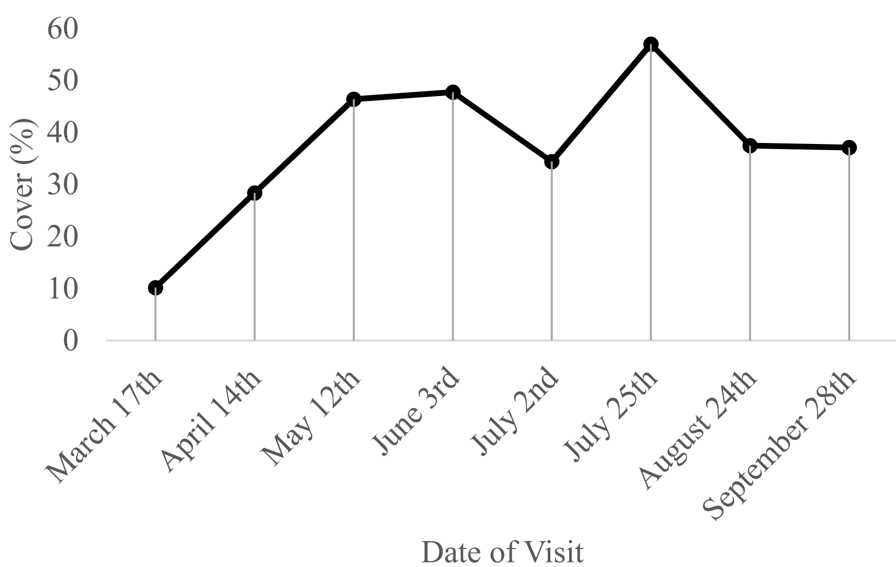

Figure 11. Graph showing the percent cover of all documented taxa in the dolomite glades during each visit of the 2018 field season. Figure by Brittney Booth

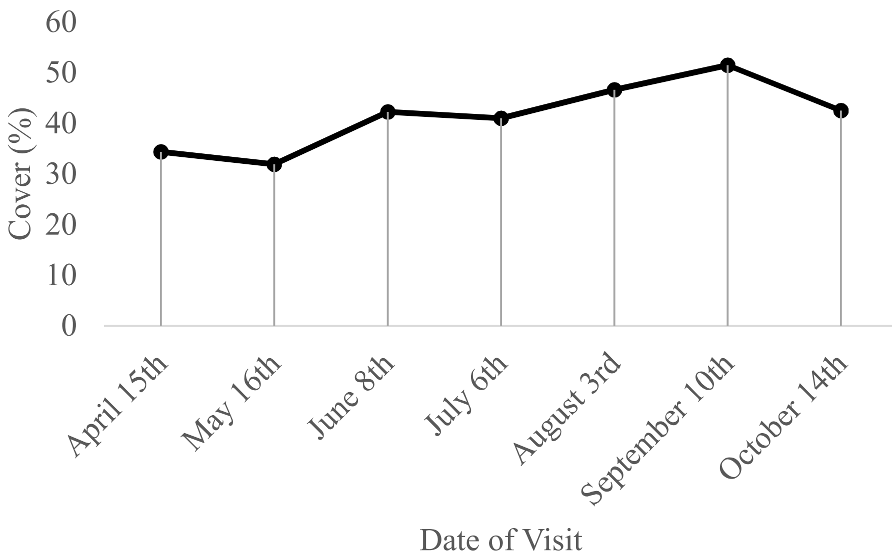

Figure 12. Graph showing the percent cover of all documented taxa in the limestone glades during each visit of the 2017 field season. Figure by Brittney Booth

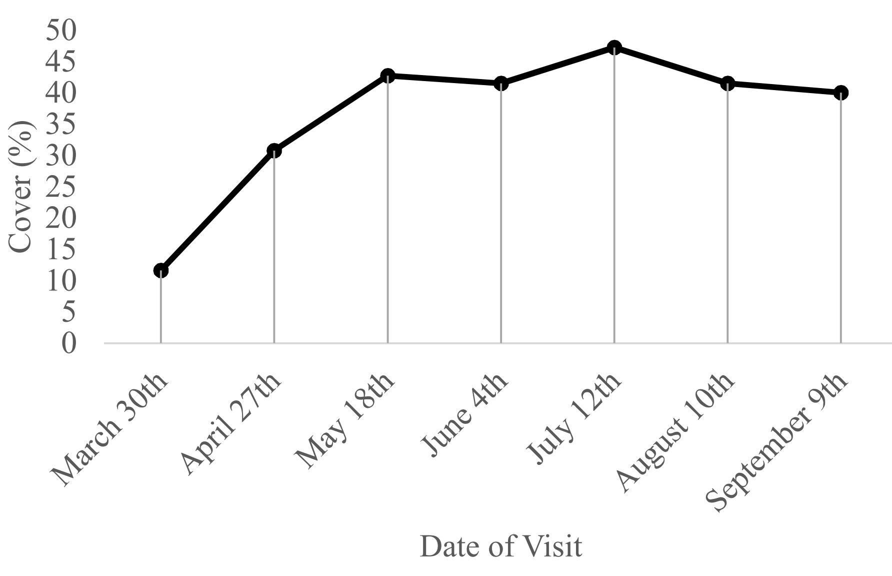

Figure 13. Graph showing the percent cover of all documented taxa in the limestone glades during each visit of the 2018 field season. Figure by Brittney Booth

Table 5. Soil pH, organic matter, and element concentrations for the five dolomite glades considered in the study. Table by Brookside Laboratories, Inc. (New Bremen, Ohio)

Sample Location	Site Description	pH	Organic Matter (ppm)	Ca (ppm)	Mg (ppm)	K (ppm)	Na (ppm)	H (ppm)
G1	Dolomite glade 1	7.8	99800	3512	1202	233	18	0
G2	Dolomite glade 2	8.0	57600	2797	1120	165	13	0
G3	Dolomite glade 3	8.0	72800	6777	1133	160	16	0
G4	Dolomite glade 4	8.1	64300	5787	1049	240	12	0
G5	Dolomite glade 5	7.9	44000	2657	928	133	11	0

Table 6. Soil pH, organic matter, and element concentrations for the five limestone glades considered in the study. Table by Brookside Laboratories, Inc. (New Bremen, Ohio)

Sample Location	Site Description	pH	Organic Matter (ppm)	Ca (ppm)	Mg (ppm)	K (ppm)	Na (ppm)	H (ppm)
L1	Limestone glade 1	7.4	78500	12022	57	104	14	0
L2	Limestone glade 2	7.5	110500	3832	160	124	14	0
L3	Limestone glade 3	6.8	87800	3934	179	142	12	30000
L4	Limestone glade 4	7.2	71000	3828	73	123	12	0
L5	Limestone glade 5	7.5	68700	3044	53	88	15	0

Table 7. Mean values and range of values for soil pH, organic matter, and element concentrations for the five limestone glades and the five dolomite glades investigated in the study. Table adapted from Brookside Laboratories, Inc. (New Bremen, Ohio)

Sample Location	Site Description	pH	Organic Matter (ppm)	Ca (ppm)	Mg (ppm)	K (ppm)	Na (ppm)	H (ppm)
L	All limestone glades	7.28	83300	5332	104	116	13	6000
G	All dolomite glades	7.96	67700	4306	1086	186	14	0
Range for L	Range of values for limestone glades	6.8-7.5	68700-110500	3044-12022	53-179	88-142	12-15	0-30000
Range for G	Range of values for dolomite glades	7.8-8.1	44000-99800	2657-6777	928-1202	133-240	11-18	0

Discussion

As already noted, a higher number of taxa was documented for the dolomite glades than for the limestone glades, as well as a higher number of unique taxa only found in the dolomite glades than there were unique taxa only found in the limestone glades. The average species richness per glade for the dolomite glades during the 2017 field season was higher than the average species richness per glade for the limestone glades during the 2017 field season (Tables 8 and 9). The average species richness per glade for the dolomite glades during the 2018 field season was also higher than the average species richness per glade for the limestone glades during the 2018 field season.

The average total abundance per glade, using individual stem counts, for the dolomite glades during the 2017 field season was double the average total abundance per glade, using individual stem counts, for the limestone glades during the 2017 field season. The average total abundance per glade, using individual stem counts, for the dolomite glades during the 2018 field season was higher, by approximately 10 individual stems, than the average total abundance per glade, using individual stem counts, for the limestone glades during the 2018 field season. The analysis of species richness and abundance shows that the dolomite glades typically had a higher number of taxa found and a higher number of total individual stems per season than the limestone glades.

The average Shannon's diversity index per glade for the dolomite glades in the 2017 field season was higher than the average Shannon's diversity index per glade for the limestone glades in the 2017 field season (Tables 8 and 9). However, the average Simpson's diversity index per glade for the dolomite glades and limestone glades in the 2017 field season was the same. The average Shannon's diversity index per glade for the dolomite glades in the 2018 field season was

lower, by only two hundredths of a decimal place, than the average Shannon's diversity index per glade for the limestone glades in the 2018 field season. The average Simpson's diversity index per glade for the dolomite glades and limestone glades in the 2018 field season was the same. The analysis of the diversity of the dolomite and limestone glades, using two different indices over two field seasons, shows very little difference in the overall diversity of the two glade types meaning that one glade type is not significantly more diverse than the other.

Some factors that might account for the differences in species richness and abundance, as well as the slight difference in diversity, between the two glade types might include washouts from heavy rain, fallen trees, wild hog activity, soil composition and mechanical removal of eastern red-cedar. It was noted in the limestone glades that they experienced washouts after heavy rain more frequently than the dolomite glades, most likely due to the more severe slopes in the limestone glades which is highlighted in the drone images taken of a dolomite glade and a limestone glade. There were a higher number of fallen trees observed in the limestone glades than in the dolomite glades, which is also most likely due to the more severe slopes in the limestone glades. The washouts after heavy rain and fallen trees in the limestone glades may have contributed to the lower species richness and abundance that was documented for the limestone glades by removing individual plants from the glades and disturbing the amount of growing space available.

Wild hog activity was observed in the dolomite glades but never in the limestone glades. This is most likely due to the less severe slopes in the dolomite glades, making them more easily accessible. However, wild hog activity occurred in only a small section of one or two of the dolomite glades at a time and was only noted to occur two to five times during each field season.

As a result, wild hog activity might not have had much of an impact on the abundance and species richness of the dolomite glades.

Soil composition might also account for differences in species richness and abundance between the two glade types, as well as the slight difference in diversity. Dolomite is mostly composed of magnesium and calcium whereas limestone is mainly composed of calcium. This difference can be seen in the soil analysis (Tables 5, 6, and 7) performed for this study. The differences in the concentration of calcium and magnesium may contribute to differences in abundance of plant taxa documented in the two types of glades and the different taxa that were found overall. The pH of the limestone and dolomite glades may have also affected the taxa that were able to grow in the two glade types with a lower pH typically found in limestone glades and a higher pH found in dolomite glades.

The final factor that may have affected the species richness and abundance of the glades might have been the mechanical removal of eastern red-cedar by the Arkansas Natural Heritage Commission during the 2018 field season in two of the dolomite glades. This removal of eastern red-cedar may have affected the abundance and species richness of the dolomite glades by allowing more sunlight and nutrients for other plant species once the eastern red-cedar was removed. This study would have benefitted from a third field season in 2019 being conducted to help ascertain the effect of the eastern red-cedar removal in two of the dolomite glades after the existing herbaceous taxa or new taxa had a longer time to grow or establish themselves.

Phenology between the two types of glades differs slightly as well. The highest percent cover of all sampled taxa in the dolomite glades was approximately sixty percent and occurred during June of 2017 and July of 2018. However, the highest percent cover of all sampled taxa in the limestone glades was approximately fifty percent in September 2017 and forty-five percent in

July of 2018. The difference in the highest percent cover for 2017 and 2018 between the limestone and dolomite glades may be attributed to the severity of the slopes in the two types of glades, the severe slopes of the limestone glades making it more difficult for plants to establish themselves as fully as in the dolomite glades with their less severe slopes. The difference in the month with the highest cover for 2017 and 2018 in the limestone and dolomite glades, with the limestone glades having a higher percent cover later in the summer than the dolomite glades, may be attributed to differences in species composition.

The Lepidoptera photographed in the limestone and dolomite glades differ in terms of number of species photographed in each. A higher number of species were photographed in the dolomite glades than in the limestone glades. One reason for this difference may be the size of the glades themselves. The limestone glades are comprised of a series of smaller openings, whereas the dolomite glades are comprised of larger openings in the forest which may make it easier for Lepidoptera to find host plants. Another reason for the difference in the number of Lepidoptera photographed may be the species richness of the plant taxa in the two types of glades. One hundred three plant taxa were documented in the limestone glades and one hundred thirteen plant taxa were documented in the dolomite glades. The higher number of plant taxa in the dolomite glades might have contributed to the higher number of Lepidoptera photographed there due to the greater variety of host plants being able to support a greater variety of Lepidoptera.

The dolomite and limestone glades do share many similarities. A total of sixty-nine taxa documented in this study occur in both types of glades. In both dolomite and limestone glades little bluestem is the most abundant species and occurs in all five dolomite and all five limestone glades. On average, approximately thirty taxa are classified as common in both limestone and

dolomite glades although the particular taxa vary slightly between the two types of glades. On average, approximately twelve to thirteen taxa are classified as rare in both limestone and dolomite glades although, again, the particular taxa vary slightly between the two types of glades. Although the soil components and soil pH can differ between the two types of glades and may cause some differences in terms of species composition of the limestone and dolomite glades, it's not a such a large difference as to affect the overall diversity of the two types of glades.

In this study, the 3D dense point cloud drone images help to emphasize the difference in slope and terrain of the two glade types (Figs. 14 and 15). They help highlight the more severe slope and rough terrain of the limestone glades compared to the dolomite glades. Orthomosaic images help to emphasize the differences in size of the glade openings between the dolomite and limestone glades (Figs. 16 and 17). Some of the advantages of using drone technology for this study were that it made it possible to view an entire glade area, regardless of size, at once. The drone imaging also allows for the creation of multiple types of images such as Digital Terrain Models (DTM), which show the topography of the landscape, and Digital Surface Models (DSM), which shows the topography of the landscape as well as the heights of features on the landscape such as trees or buildings. Drone imaging over a specific area can obtain much more accurate results in terms of elevation and topography than could be obtained otherwise.

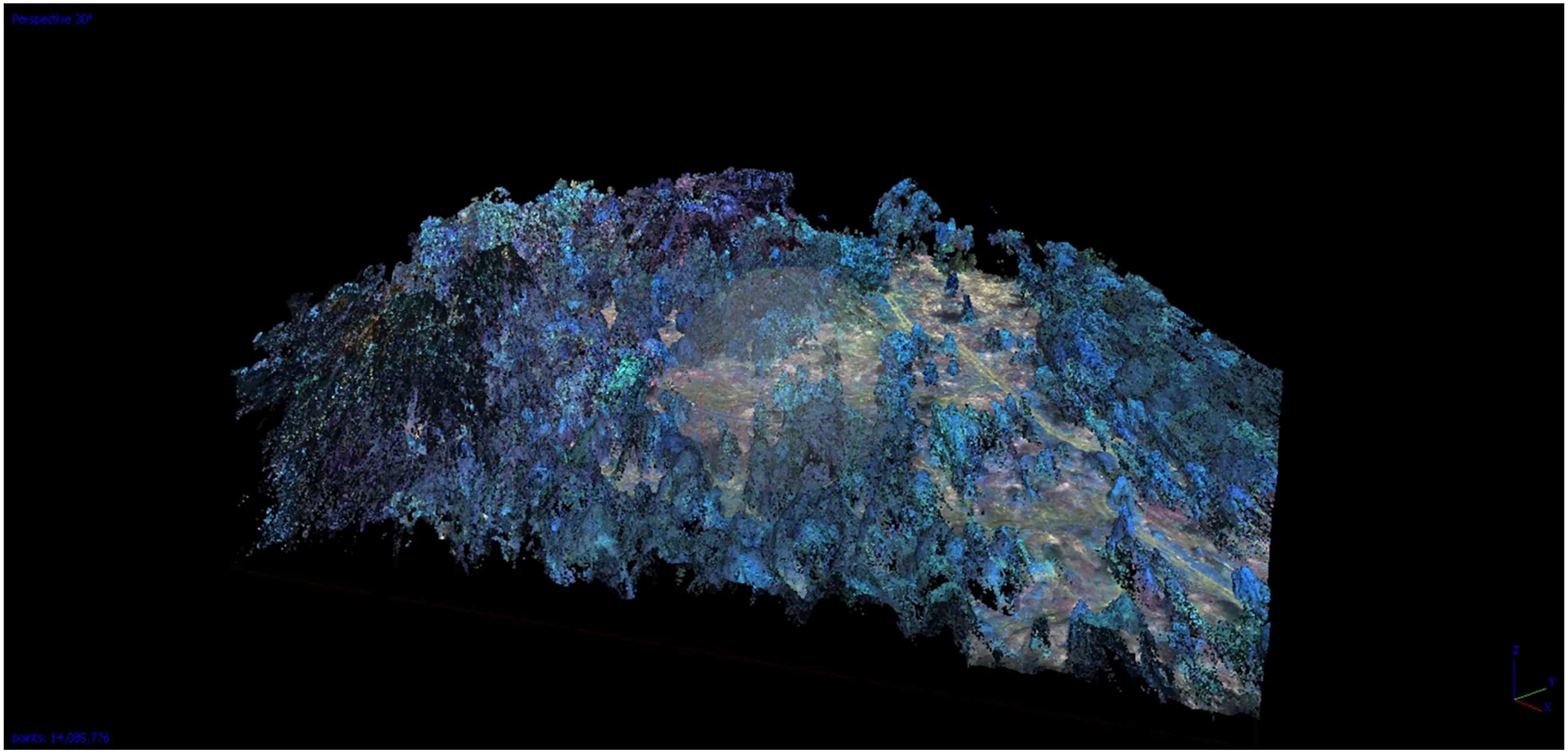

Figure 14. 3D dense point cloud image of the third dolomite glade, showing the opening of the glade surrounded by trees and the gentle slope of the glade. Image created from photos taken with a drone on May 8, 2018 and processed with Agisoft Metashape by Angie Otting.

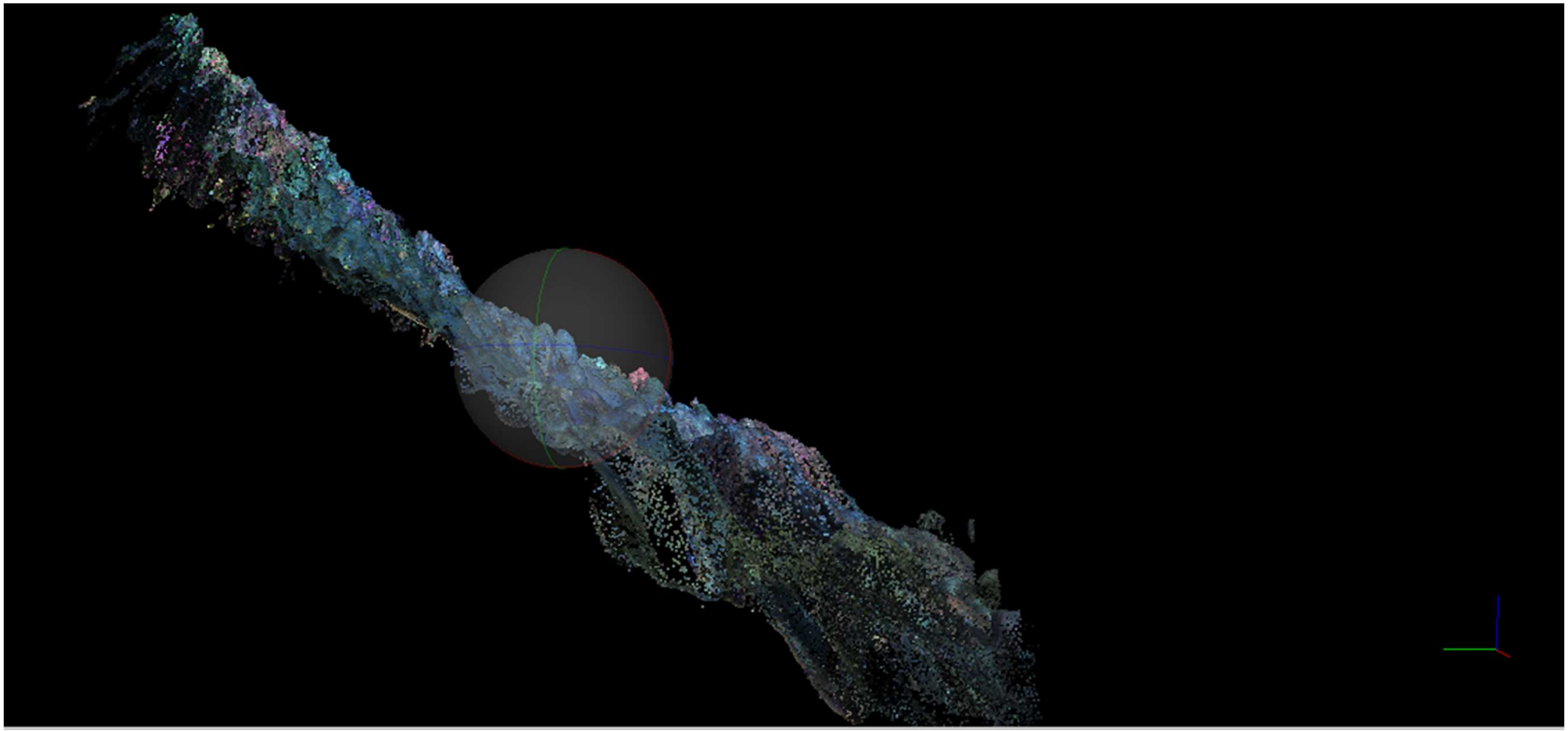

Figure 15. 3D dense point cloud image of the fourth limestone glade, showing the steeper slope of the glade. Image created from photos taken with a drone on October 24, 2018 and processed with Agisoft Metashape by Angie Otting.

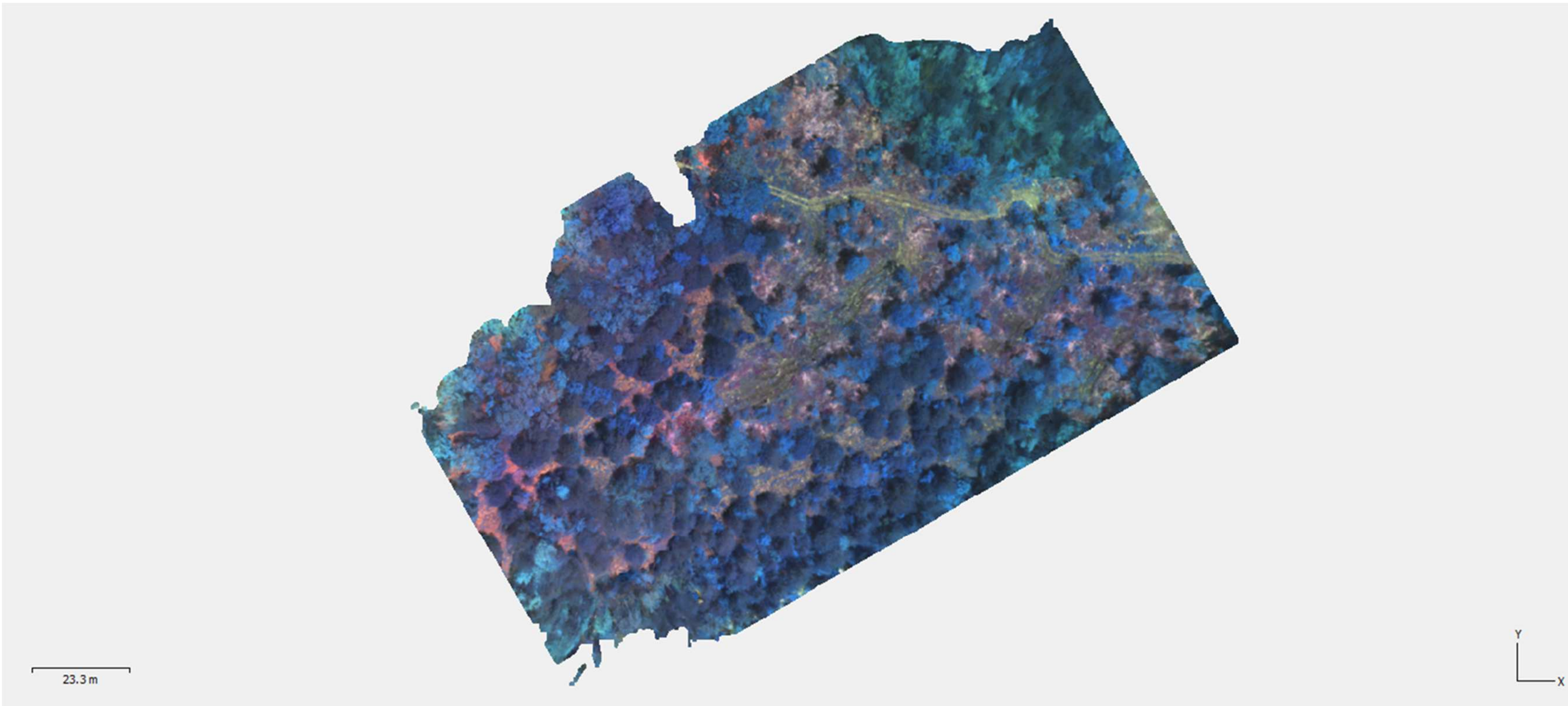

Figure 16. Orthomosaic image of the third dolomite glade, showing an aerial view of the glade openings after eastern red-cedar removal had begun in 2018. Image created from photos taken with a drone on May 8, 2018 and processed with Agisoft Metashape by Angie Otting.

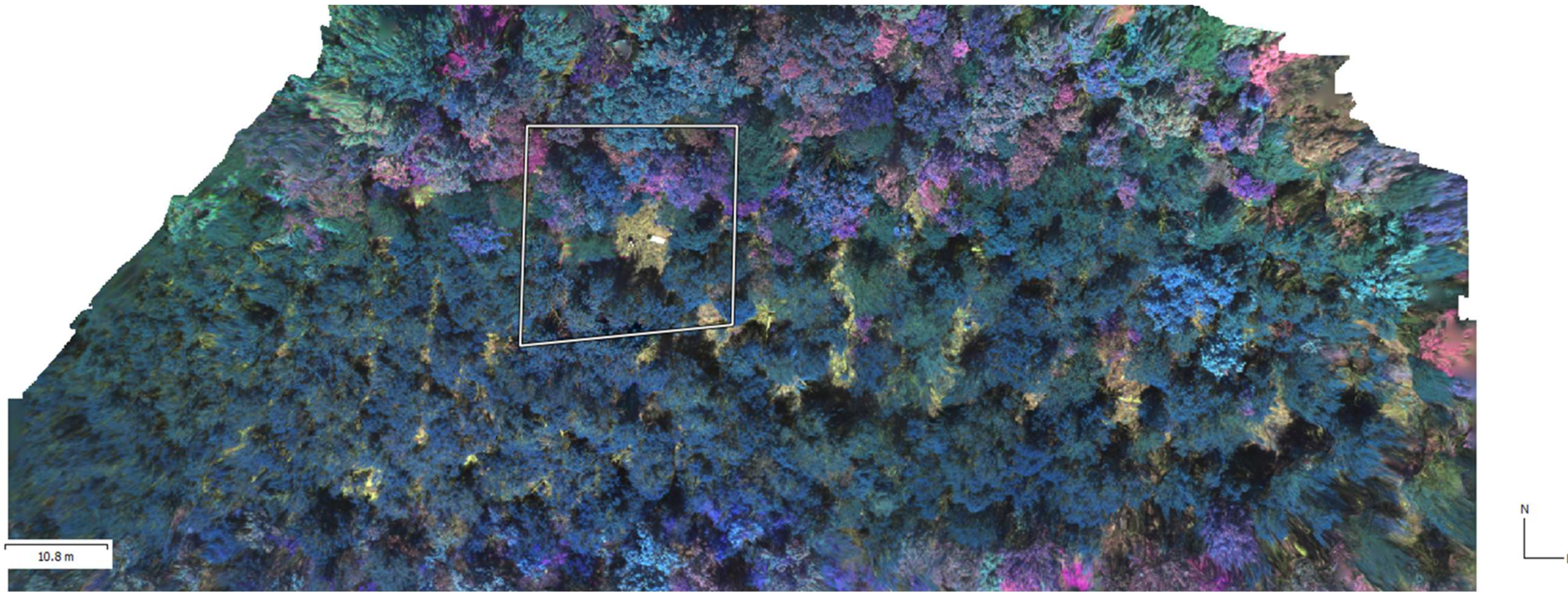

Figure 17. Orthomosaic image of the fourth limestone glade, showing an aerial view of the glade openings without eastern red-cedar removal. Image created from photos taken with a drone on October 24, 2018 and processed with Agisoft Metashape by Angie Otting.

Conclusions

From this study it can be concluded that while the overall diversity for the two glade types did not differ significantly, the total abundance, using individual stem counts, and species richness for the dolomite glades was slightly higher than that of the limestone glades. There are a multitude of factors that can account for these minor differences, including the severity of slope which can lead to washouts from heavy rain and tree fall. It would be recommended that further field studies be carried out in the dolomite glades to determine the effect of the mechanical removal of eastern red-cedar from the dolomite glades in 2018 as it could be beneficial to the glades. It would also be beneficial to obtain drone images of the limestone and dolomite glades over a period of time to determine if it's possible to follow the phenology of the different woody species as well as graminoids and forbs to determine differences and similarities between the two glade types. As a result of the diversity indices being similar, the sixty-nine taxa in common, and the minor differences in species richness and total abundance for the dolomite and limestone glades, the two types of glades could potentially be managed using similar practices, such as prescribed fire and mechanical removal of eastern red-cedar, without having detrimental effects on the diversity of the vascular plant taxa.

Figure 18. Some of the most abundant species found in limestone and dolomite glades, including (a) *Rudbeckia hirta* L., (b) *Ruellia humilis* Nutt., (c) *Grindelia lanceolata* Nutt., (d) *Symphyotrichum oblongifolium* (Nutt.) G.L.Nesom, (e) *Galactia volubilis* (L.) Britton, (f) *Tragia ramosa* Torr., (g) *Liatris hirsuta* Rydb., and (h) *Allium canadense* L. var. *lavendulare* (Bates) Ownbey & Aase. Photos by Brittney Booth

Figure 19. Some of the Lepidoptera species photographed in the limestone and dolomite glades, including (a) *Papilio troilus* subsp. *troilus* Linnaeus, 1758, (b) *Euchaetes egle* (Drury, 1773), (c) *Chlosyne nycteis* (Doubleday, [1847]), (d) *Epargyreus clarus* (Cramer, 1775), (e) *Heliothis virescens* (Fabricius, 1777), (f) *Junonia coenia* Hübner, [1822], (g) *Pontia protodice* (Boisduval & Le Conte, [1830]), (h) *Limenitis arthemis* subsp. *astyarax* (Fabricius, 1775). Photos by Brittney Booth and Karen Willard

Table 8. Average values of species richness, total abundance, Shannon Diversity Index, and Simpson's Diversity Index for the five dolomite glades investigated in the study in the years 2017 and 2018. Table by Brittney Booth

	2017	2018
Average Species Richness	10.9	9.23
Average Total Abundance	63.9	44.2
Average Shannon Diversity Index	1.96	1.77
Average Simpson's Diversity Index	0.80	0.76

Table 9. Average values of species richness, total abundance, Shannon Diversity Index, and Simpson's Diversity Index for the five limestone glades investigated in the study in the years 2017 and 2018. Table by Brittney Booth

	2017	2018
Average Species Richness	9	8.78
Average Total Abundance	30.9	33.8
Average Shannon Diversity Index	1.87	1.79
Average Simpson's Diversity Index	0.80	0.76

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Appendix

Taxa recorded during the present study. Nomenclature follows Gentry et al. (2013).

[1] Indicates species or taxa documented only in the dolomite glades
[2] Indicates species or taxa documented only in the limestone glades

Family	Taxon	Common name
Acanthaceae	*Ruellia humilis* Nutt.	hairy wild petunia
Agavaceae	*Camassia scilloides* (Raf.) Cory	wild hyacinth
Agavaceae	*Manfreda virginica* (L.) Salisb. ex Rose	false aloe
Alliaceae	*Allium canadense* L. var. *lavendulare* (Bates) Ownbey & Aase	tall pink glade onion
Alliaceae[1]	*Allium stellatum* Nutt. ex Ker Gawl.	glade onion
Alliaceae	*Nothoscordum bivalve* (L.) Britton in Britton & A.Br.	crow-poison
Alliaceae[1]	Unknown sp. A	
Anacardiaceae	*Rhus aromatica* Aiton var. *aromatica*	fragrant sumac
Anacardiaceae[2]	*Rhus copallinum* L.	winged sumac
Apiaceae[2]	*Eryngium yuccifolium* Michx.	rattlesnake-master
Apiaceae	*Sanicula* sp.	black-snakeroot
Apiaceae[2]	*Taenidia integerrima* (L.) Drude	yellow pimpernel
Apiaceae[2]	*Zizia aurea* (L.) W.D.J.Koch	golden Alexanders
Apocynaceae[1]	*Apocynum cannabinum* L.	dogbane
Apocynaceae	*Asclepias quadrifolia* Jacq.	four-leaf milkweed
Apocynaceae	*Asclepias verticillata* L.	whorled milkweed

Appendix contd.

Family	Taxon	Common name
Apocynaceae	*Asclepias viridis* Walter	green milkweed
Aquifoliaceae[1]	*Ilex decidua* Walter	deciduous holly
Asteraceae	*Antennaria* sp.	pussytoes
Asteraceae	*Coreopsis lanceolata* L.	lance-leaf tickseed
Asteraceae[2]	*Coreopsis palmata* Nutt.	tickseed
Asteraceae	*Echinacea pallida* (Nutt.) Nutt.	pale purple coneflower
Asteraceae[1]	*Erigeron strigosus* Muhl. ex Willd.	daisy fleabane
Asteraceae[1]	*Eupatorium altissimum* L.	tall thoroughwort
Asteraceae	*Grindelia lanceolata* Nutt.	gum-plant
Asteraceae	*Helianthus hirsutus* Raf.	hairy woodland sunflower
Asteraceae	*Helianthus maximiliani Schrad.*	Maximilian's sunflower
Asteraceae[1]	*Liatris aspera* Michx.	rough blazing-star
Asteraceae	*Liatris hirsuta* Rydb.	hairy blazing-star
Asteraceae	*Liatris punctata* Hook. var. *mucronata* (DC.) B.L.Turner in B.L.Turner et al.	dotted gayfeather
Asteraceae	*Palafoxia callosa* (Nutt.) Torr. & A.Gray	small palafoxia
Asteraceae[2]	*Parthenium integrifolium* L.	wild quinine
Asteraceae	*Rudbeckia hirta* L.	black-eyed Susan

Appendix contd.

Family	Taxon	Common name
Asteraceae	*Rudbeckia missouriensis* Englem. ex C.L.Boynton & Beadle	Missouri coneflower
Asteraceae[1]	*Silphium laciniatum* L.	compass-plant
Asteraceae	*Silphium terebinthinaceum* Jacq. var. *terebinthinaceum*	prairie-dock
Asteraceae	*Solidago* sp.	goldenrod
Asteraceae[1]	*Solidago gattingeri* Chapm. ex A.Gray in A.Gray et al.	Gattinger's goldenrod
Asteraceae[2]	*Symphyotrichum anomalum* (Engelm. ex Torr. & A.Gray) G.L.Nesom	aster
Asteraceae	*Symphyotrichum oblongifolium* (Nutt.) G.L.Nesom	aromatic aster
Asteraceae[2]	*Symphyotrichum patens* (Aiton) G.L.Nesom var. *patentissimum* (Lindl. ex DC.) G.L.Nesom	late purple aster
Asteraceae[1]	*Symphyotrichum urophyllum* (Lindl. ex DC.) G.L.Nesom	white arrow-leaf aster

Appendix contd.

Family	Taxon	Common name
Asteraceae[1]	*Vernonia arkansana* DC. in DC. & A.DC.	Arkansas ironweed
Asteraceae[1]	Unknown sp. I	
Asteraceae[1]	Unknown sp. J	
Asteraceae[1]	Unknown sp. K	
Betulaceae	*Ostrya virginiana* (Mill.) K.Koch	hop-hornbeam
Boraginaceae	*Heliotropium tenellum* (Nutt.) Torr.	heliotrope
Boraginaceae	*Lithospermum canescens* (Michx.) Lehm.	hoary puccoon
Boraginaceae[1]	*Onosmodium bejariense* A.DC. var. *subsetosum* (Mack. & Bush ex Small) B.L.Turner	marbleseed
Cactaceae[2]	*Opuntia humifusa* (Raf.) Raf. var. *humifusa*	eastern prickly-pear
Campanulaceae	*Lobelia spicata* Lam.	pale-spike lobelia
Caryophyllaceae[1]	*Minuartia patula* (Michx.) Mattf.	sandwort
Commelinaceae[2]	*Tradescantia ohiensis* Raf.	Ohio spiderwort
Crassulaceae[2]	*Sedum pulchellum* Michx.	widow's-cross
Cupressaceae	*Juniperus virginiana* L. var. *virginiana*	eastern red-cedar
Cyperaceae	*Carex crawei* Dewey	Crawe's sedge

Appendix contd.

Family	Taxon	Common name
Cyperaceae	*Carex eburnea* Boott in Hook.	sedge
Cyperaceae[1]	*Carex meadii* Dewey	Mead's sedge
Cyperaceae[1]	*Eleocharis compressa* Sull. var. *compressa*	flat-stem spike-rush
Cyperaceae[1]	*Fimbristylis puberula* (Michx.) Vahl var. *puberula*	fimbry
Cyperaceae[1]	*Scleria oligantha* Michx.	nut-rush
Cyperaceae[2]	*Scleria pauciflora* Muhl. ex Willd. var. *pauciflora*	nut-rush
Cyperaceae[1]	Unknown sp. B	
Cyperaceae[2]	Unknown sp. C	
Cyperaceae[1]	Unknown sp. D	
Cyperaceae	Unknown sp. E	
Cyperaceae	Unknown sp. F	
Cyperaceae[2]	Unknown sp. G	
Ebenaceae[1]	*Diospyros virginiana* L.	persimmon
Euphorbiaceae	*Acalypha monococca* (Engelm. ex A.Gray) Lill.W.Mill. & Gandhi	one-seed mercury

Appendix contd.

Family	Taxon	Common name
Euphorbiaceae[1]	*Croton capitatus* Michx.	woolly croton
Euphorbiaceae	*Croton monanthogynus* Michx.	prairie-tea
Euphorbiaceae	*Euphorbia corollata* L.	flowering spurge
Euphobriaceae	*Euphorbia dentata* Michx.	toothed spurge
Euphorbiaceae[1]	*Euphorbia missurica* Raf.	Missouri spurge
Euphorbiaceae	*Tragia ramosa* Torr.	noseburn
Fabaceae[2]	*Astragalus crassicarpus* Nutt. var. *trichocalyx* (Nutt.) Barneby	cream ground-plum
Fabaceae	*Baptisia australis* (L.) R.Br. in W.T.Aiton var. *minor* (Lehm.) Fernald	blue wild indigo
Fabaceae[2]	*Baptisia bracteata* Muhl. ex Elliott var. *leucophaea* (Nutt.) Kartesz & Gandhi	cream wild indigo
Fabaceae	*Cercis canadensis* L. var. *canadensis*	eastern redbud
Fabaceae	*Chamaecrista fasciculata* (Michx.) Greene var. *fasciculata*	showy partridge-pea
Fabaceae	*Dalea purpurea* Vent. var. *purpurea*	purple prairie-clover
Fabaceae[2]	*Desmodium perplexum* B.G.Schub.	tick-trefoil

Appendix contd.

Family	Taxon	Common name
Fabaceae	*Galactia volubilis* (L.) Britton	downy milk-pea
Fabaceae[2]	*Lespedeza violacea* (L.) Pers.	bush-clover
Fabaceae[2]	*Lespedeza virginica* (L.) Britton	slender bush-clover
Fabaceae	*Mimosa quadrivalvis* L. var. *nuttallii* (DC. ex Britton & Rose) Beard ex Barneby	sensitive-brier
Fabaceae[2]	*Stylosanthes biflora* (L.) Britton, Sterns & Poggenb.	pencil-flower
Fabaceae[2]	Unknown sp. H	
Fagaceae	*Quercus muehlenbergii* Englem.	chinquapin oak
Fagaceae[1]	*Quercus rubra* L.	northern red oak
Fagaceae[2]	*Quercus stellata* Wangenh.	post oak
Fagaceae	*Quercus velutina* Lam. in Lam. et al.	black oak
Gentianaceae	*Sabatia angularis* (L.) Pursh	rose-gentian
Geraniaceae	*Geranium* sp.	geranium
Hypericaceae[2]	*Hypericum pseudomaculatum* Bush ex Britton	false spotted St. John's-wort
Hypericaceae[1]	*Hypericum sphaerocarpum* Michx.	round-fruit St. John's-wort
Hypoxidaceae[1]	*Hypoxis hirsuta* (L.) Coville	yellow star-grass

Appendix contd.

Family	Taxon	Common name
Iridaceae	*Sisyrinchium campestre* E.P.Bicknell	blue-eyed-grass
Juglandaceae[2]	*Carya* sp.	hickory
Lamiaceae[1]	*Belphilia ciliata* (L.) Benth.	downy wood mint
Lamiaceae	*Clinopodium arkansanum* (Nutt.) House	Arkansas calamint
Lamiaceae[2]	*Cunila origanoides* (L.) Britton	dittany
Lamiaceae[2]	*Physostegia virginiana* (L.) Benth. subsp. *praemorsa* (Shinners) P.D.Cantino	obedient-plant
Lamiaceae	*Scutellaria parvula* Michx. var. *parvula*	small skullcap
Lauraceae	*Sassafras albidum* (Nutt.) Nees	sassafras
Liliaceae[1]	*Erythronium* sp.	trout-lily
Malvaceae	*Callirhoe digitata* Nutt.	winecup
Oleaceae[1]	*Fraxinus quadrangulata* Michx.	blue ash
Onagraceae[1]	*Oenothera macrocarpa* Nutt. subsp. *macrocarpa*	Missouri-primrose
Ophioglossaceae[1]	*Ophioglossum engelmannii* Prantl	limestone adder's-tongue fern
Orchidaceae[1]	*Spiranthes cernua* (L.) Rich.	nodding ladies'-tresses
Orobanchaceae[2]	*Aureolaria grandiflora* (Benth.) Pennell	yellow false foxglove
Orobanchaceae[1]	*Castilleja coccinea* (L.) Spreng.	Indian-paintbrush

Appendix contd.

Family	Taxon	Common name
Oxalidaceae	*Oxalis violacea* L.	violet wood-sorrel
Passifloraceae	*Passiflora lutea* L.	yellow passion-flower
Phyllanthaceae[1]	*Phyllanthus polygonoides* Nutt. ex	knotweed leaf-flower
Plantaginaceae[2]	*Penstemon arkansanus* Pennell	Arkansas beardtongue
Poaceae	*Andropogon gerardii* Vitman	big bluestem
Poaceae	*Bouteloua curtipendula* (Michx.) Torr. var. *curtipendula*	side-oats grama
Poaceae	*Danthonia spicata* (L.) P.Beauv. ex Roem. & Schult.	poverty oat grass
Poaceae	*Dichanthelium acuminatum* (Sw.) Gould & C.A.Clark subsp. f*asciculatum* (Torr.) Freckmann & Lelong	hairy rosette grass
Poaceae[1]	*Panicum flexile* (Gatt.) Scribn.	wiry witch grass
Poaceae	*Panicum virgatum* L.	switch grass
Poaceae	*Schizachyrium scoparium* (Michx.) Nash var. *scoparium*	little bluestem
Poaceae[1]	*Sorghastrum nutans* (L.) Nash	Indian grass
Poaceae[1]	*Tridens flavus* (L.) Hitchc. var. *flavus*	purple-top tridens

Appendix contd.

Family	Taxon	Common name
Poaceae[1]	*Tripsacum dactyloides* (L.) L.	eastern gama grass
Polemoniaceae[1]	*Phlox pilosa* L. subsp. *ozarkana* (Wherry) Wherry	Ozark downy phlox
Primulaceae[1]	*Primula meadia* (L.) Mast & Reveal	shooting star
Pteridaceae[1]	*Pellaea atropurpurea* (L.) Link	purple-stem cliff-brake
Ranunculaceae	*Delphinium treleasei* Bush ex K.C.Davis	Trelease's larkspur
Rhamnaceae	*Berchemia scandens* (Hill) K.Koch	rattan-vine
Rhamnaceae[1]	*Frangula caroliniana* (Walter) A.Gray	Carolina buckthorn
Rosaceae[2]	*Rosa carolina* L.	Carolina rose
Rosaceae[1]	*Rosa setigera* Michx.	climbing rose
Rubiaceae[2]	*Galium arkansanum* A.Gray var. *arkansanum*	Arkansas bedstraw
Rubiaceae	*Galium virgatum* Nutt. ex Torr. & A.Gray	southwestern bedstraw
Rubiaceae[2]	*Houstonia longifolia* Gaertn.	long-leaf bluet
Rubiaceae	*Houstonia nigricans* (Lam.) Fernald var. *nigricans*	diamond-flower

Appendix contd.

Family	Taxon	Common name
Santalaceae[1]	*Comandra umbellata* (L.) Nutt. subsp. *umbellata*	bastard-toadflax
Sapotaceae	*Sideroxylon lanuginosum* Michx.	gum bumelia
Smilacaceae	*Smilax bona-nox* L.	saw greenbrier
Ulmaceae	*Ulmus alata* Michx.	winged elm
Valerianaceae[2]	*Valerianella ozarkana* Dyal	Ozark cornsalad
Verbenaceae[2]	*Glandularia canadensis* (L.) Nutt.	rose vervain
Violaceae	*Viola pedata* L.	bird's-foot violet
Vitaceae	*Parthenocissus quinquefolia* (L.) Planch.	Virginia-creeper